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THE MONTANA STATE BOARD OF ENTOMOLOGY

FOURTH BIENNIAL REPORT

1919-1920

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ENTOMOLOGY

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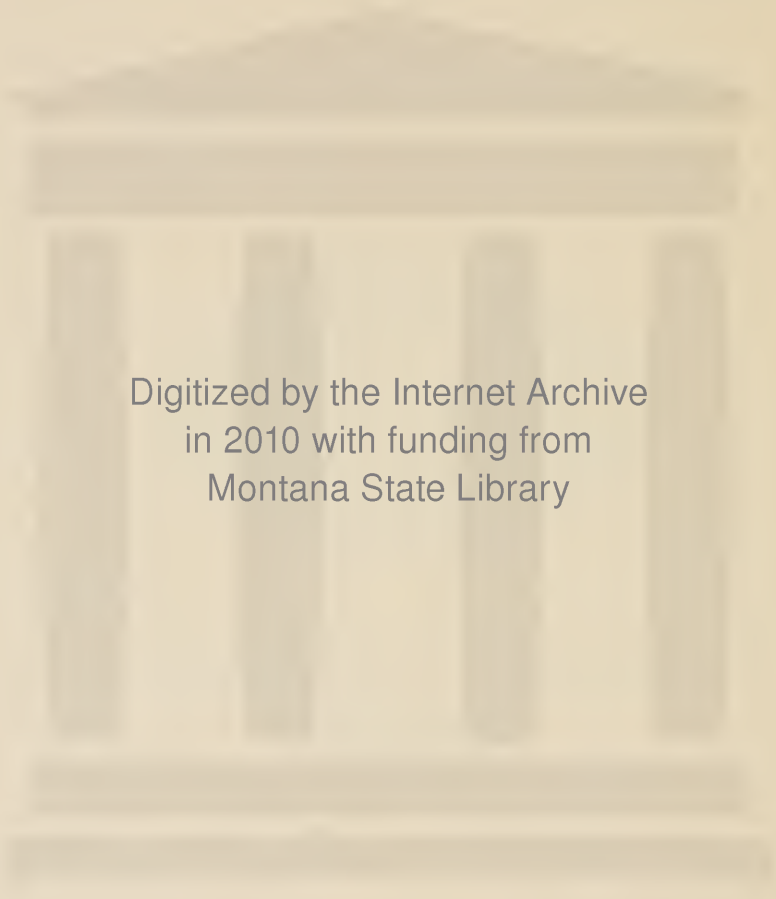
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MONTANA STATE BOARD OF ENTOMOLOGY.

W. F. COGSWELL, M. D., Secretary State Board of Health, Chairman ..... Helena, Montana

W. J. BUTLER, D. V. S., State Veterinary Surgeon, Member ..... Helena, Montana

R. A. COOLEY, B. Sc., State Entomologist, Secretary ..... Bozeman, Montana

LETTER OF TRANSMITTAL.

Bozeman, Montana, January 1, 1921.

To His Excellency,
Governor Joseph M. Dixon,
Helena, Mont.

My Dear Sir:

Acting for the Montana State Board of Entomology, I have the honor to transmit to you the Fourth Biennial Report.

A few outstanding facts should be brought to your attention. While very distinct progress has been made in the alleviation of the serious situation which formerly existed with respect to Rocky Mountain spotted fever in the Bitter Root Valley, the time has come for a radical departure from our present procedure. The number of cases has been greatly reduced and ticks are very much less abundant in the valley, but back in the mountains, where the disease has been present as far back as we have any knowledge, there has been no change. Further work along the same lines as are now being conducted will further reduce the fever cases and ticks but the results of our efforts cannot be looked upon as permanent unless we remedy the condition back in the mountains. The next step in real progress is to conduct an investigaton on the real source from which ticks become infected.

The Board has authorized the request for an increased appropriation in order that this investigation may be conducted.

Very respectfully,

R. A. COOLEY, Secretary.

FOURTH BIENNIAL REPORT OF THE MONTANA STATE BOARD OF ENTOMOLOGY.

By R. A. COOLEY, Secretary.

During the two-year period now closing the efforts of the Board of Entomology have been devoted almost exclusively to the eradication or control of the spotted fever tick, **Dermacentor venustus Banks,** in western Montana. In 1917 and previously the work of eradication was conducted under a plan of cooperation between the U. S. Public Health Service and the U. S. Bureau of Entomology for the federal government and the Board of Entomology for the State of Montana. Since that time the Board has operated alone, supported by the Board of Entomology fund. Our state appropriation up to 1919 was $5,000 per annum, but the last session of the legislature increased the sum of $8,500. Appeal was made to the U. S. Bureau of Biological Survey for assistance in poisoning ground squirrels on federal lands bordering the areas where the state was conducting its work and this Bureau has cooperated by furnishing funds for poison and labor. The Board of Entomology takes great pleasure in acknowledging the assistance rendered by the Bureau of Biological Survey and also expresses its appreciation of the continued cooperation and interest of the U. S. Forestry Service.

As previously, the work has been under the direct charge of R. R. Parker, Ph. D., Assistant Entomologist of the Board. The Board believes itself to be very fortunate in having in charge a person of such training, thoroughness and energy as Dr. Parker possesses. A tremendous amount of detail is necessarily involved in carrying on this work. It is necessary to be constantly in touch with every person residing in the districts and to possess full and up-to-date information regarding every piece of land, the amount and kind of live stock on every farm, the condition of fences and numerous other details. Accordingly, it has been necessary to erect and maintain an elaborate system of records. Each worker in the field is thus in possession of full detailed instructions to guide him in his work with the farmers and he in turn makes detailed reports on each day's operation. Everything that happens is made a matter of record.

Dr. Parker's report to the Board of Entomology is given herewith, complete, since it furnishes, in full summary, the operations of the Board during the seasons of 1919 and 1920.

The eradication or control procedure as now in force is concerned primarily with the destruction of the ground squirrels which harbor the immature stages of the tick and the prevention of the adult ticks from feeding on domestic animals—horses and cows principally. The last legislature passed a measure (Chapter 27, Session Laws of 1918) enlarging the authority of the Board of Entomology, and regulating the grazing of domestic animals on unfenced lands and roadsides. After two years of operation with this law the Board wishes to state that the law is a good one and with it we have been able to accomplish much more than we could have accomplished without it.

Prevalence of Spotted Fever in Montana.

Attention has been given to bringing together reliable information regarding the prevalence of Rocky Mountain spotted fever in Montana. In the tables here given this information is shown in detail and is the most complete that has yet been published. We recognize two types of the disease in Montana, a severe type with a much higher percentage of mortality in Missoula and Ravalli Counties, and a milder type scattered through other parts of the state in which the percentage of mortality is very low.

It is a remarkable thing that up to 1915 there had been very few cases in eastern Montana, an exception being that in Carbon County we have had a few scattering cases for many years back. In 1915 thirty-five cases suddenly appeared and there have been scattering cases ever since.

The following table shows the cases in eastern Montana since 1914:

Rocky Mountain spotted fever cases in counties other than Missoula and Ravalli, beginning in 1914, the first year that the diseases showed a wide distribution within the State.

Counties	1914	1915	1916	1917	1918	1919	1920
Big Horn[1]	....	2	....	....	....	1	1
Broadwater	....	....	....	1	....	....	1
Carbon[2]	2	3	1	4	2	1	1
Carter	....	4	....	....	....	....	....
Cascade	....	1[3]	....	....	....	....	....
Custer[4]	....	6	....	....	....	....	....
Daniels	....	....	....	....	....	1	....
Fergus[5]	....	....	1	3	....	2	3
Gallatin[6]	....	2	....	....	....	....	....
Garfield	....	5	3	1	....	....	1
Golden Valley	....	....	....	1[7]	....	....	....
Granite[8]	....	....	1	....	....	....	....
Lewis and Clark	....	....	....	....	....	1	3
Madison	....	....	....	2	1	....	....
Musselshell	1	2	6	1	2	1	10
Park[10]	....	....	....	....	....	....	....
Prairie	....	1	....	1	....	....	....
Powder River[11]	....	4	....	....	....	....	....
Richland	1	....	....	....	....	....	....
Rosebud	....	3	....	....	1[12]	1	1
Stillwater	....	....	....	2	....	....	....
Treasure	....	2	1	....	....	....	....
Yellowstone[13]	....	....	1	3[14]	....	1	....
Valley	....	....	1	....	....	....	....
Wibaux	....	....	....	....	1	....	....

1 Two doubtful cases in 1901.
2 17 cases between 1894 and 1904, records between 1904 and 1914 incomplete.
3 Brought in from Idaho.
4 Uncertain occurrence before 1915.
5 Doubtful case in 1904.
6 Locality of infection doubtful.
7 Brought in from Idaho.
8 Earlier cases between 1891 and 1904.
9 One case uncertain.
10 Doubtful case in 1904.
11 Uncertain cases prior to 1915.
12 Uncertain case.
13 Uncertain case in 1904.
14 Two cases brought in from Wyoming.
15 Close to Dakota line.

The following table of cases in western Montana dates back to 1913 when the work of this Board began and active operations against the tick were taken up. The number of cases up to that time had ranged from 8 to 28 in these counties and it will be noted that in 1913 and 1914, before our work was well under way, the number kept up, and later went down.

Missoula and Ravalli County Cases Since 1913.

COUNTY	1913	1914	1915	1916	1917	1918	1919	1920
Missoula	....	5	5	1	1	1	2	2
Ravalli	....	7	3	5	5	2	3	2
TOTALS	11	12	8	6	6	3	5	4

In addition to these cases in Ravalli County there was one other case which originated in the state of Idaho in 1915.

Organization.

The law designates that the Board of Entomology shall be made up ....of the Secretary of the State Board of Health, the State Veterinary Surgeon, and the State Entomologist. Its duties are wholly concerned with the investigation and control or eradication of insects concerned in the transmission of diseases of human beings or domestic animals. It is not, therefore, concerned with the control of crop pests. The Board of Health Secretary is Chairman and the State Entomologist is Secretary. The field of operation of this Board as defined by law is rather broad. It would be within its province to take up the study of any insect which is responsible for a serious disease of man or domestic animals. However, up to the present time its efforts have been confined almost exclusively to the spotted fever tick. Some attention a few years ago was given to the tick in the eastern part of Montana but with the departure of the federal agencies previously mentioned it becomes necessary for us to concentrate in the Bitter Root Valley in order that we should not lose what had been accomplished there. The Board maintains field headquarters at Victor, Ravalli County, and from these headquarters the spotted fever tick work is managed.

Dr. Parker is in charge of the field organization and has under him a chief deputy who has charge of dipping operations, filling of the dipping vats and field work generally. A deputy is in charge of each district. This district deputy has charge of vats, hiring and discharge of ground squirrel poisoners, distributing poison to farmers, and quarantine and grazing regulations. It is the particular province of this man to be informed in much detail regarding each man's property, fences, and the exact locations as to where ticks and squirrels are most abundant. His full time is spent in the field and he does the actual work of

supervising squirrel poisoners, dipping of stock, etc. The total number of men employed in the Bitter Root Valley varies between twenty and thirty during the active season; that is, no field work is being done during most of the year because of the absence of squirrels and because ticks are prevalent only in the spring. From the middle of March on through July the work of the Board is pushed.

The Biological Survey has cooperated with us in the destruction of squirrels on the forest reserve bordering the valley and on their public lands. This Bureau has furnished the funds and the Board's representative has conducted the work, hired the men, and dispensed the poison. The Forest Service is willing and would cooperate but for the fact that no money has been allowed the local office for this purpose. The county work is done by our organization and bills are collected or charged against the property and collected with taxes in accordance with the law.

The O'Brien Creek District.

In the last report a detailed list and descriptions of the control districts were given. They ....were the Florence, Stevensville, Victor, Hamilton, and Gold Creek districts. To these has been added during 1920 the O'Brien Creek District, the description and boundaries of which follow:

North and East Boundary. Beginning at the point where the main channel of the Clark Fork River or the Missoula River crosses the range line between Range 20 West and Range 21 West, thence eastward along the main channel of the Clark Fork River or Missoula River to the point of its confluence with the Bitter Root River, and thence along the channel of the Bitter Root River to the point of its confluence with Hayes Creek.

South Boundary. Hayes Creek from the point of its confluence with the main channel of the Bitter Root River, westward to the point where Hayes Creek crosses the range line between Range 20 West and Range 21 West.

West Boundary. Beginning at the point where Hayes Creek crosses the range line between Range 20 West and Range 21 West, thence northward along the range line to the point of beginning.

The region in which we are operating extends, therefore, from Lost Horse Creek at the south end of the Valley near Como to the north boundary of Ravalli county near Carlton, and then follows a gap from the Missoula county boundary northward where no work is being done until the O'Brien Creek District is reached. The O'Brien Creek Distric is opposite the Military Reservation and is only a few miles out of Missoula. A considerable number of deaths have occurred in this general locality in the past few years.

Further Investigation Necessary.

In the various publications of the Board of Entomology and of the Experiment Station has been given the information on which is based our program of tick reduction. This is reviewed again in Dr. Parker's paper in this report. It should be borne in mind that up to the present time the investigations of pathologists and entomologists have shown that in order to bring this disease under control it will be necessary to destroy the tick. Not much progress has been made in the control of the disease after the patient is once infected. It is possible that new and valuable information may be secured now that the germ of the disease has been discovered, but up to the present time our only hope of bringing the situation under control has been by way of tick reduction.

It should be borne in mind further that spotted fever is not confined to Montana. It extends throughout the northwestern states, even down as far as the northern part of California and is of tremendous importance to the nation. It is, however, of particular importance to the State of Montana because this state is looked upon by professional men and the public generally throughout the United States as especially the home of this disease. This is undoubtedly due to the fact that we have in the western part of this state one locality in which the disease is practically always fatal to human beings. This fact in early years produced an unreasonable scare and has hurt western Montana and the whole of the state in the eyes of the other states. Idaho has had as high as 400 cases in a single year, and, while the cases have been less than one per cent fatal in that state and in that respect comparing very favorably with the strain of the disease in western Montana, it should be borne

in mind that this is at best a very serious disease, ranking perhaps with scarlet fever or typhoid fever wherever it occurs. In another section in this rpeort is given in tabular form a list of the cases in this state by counties, so far as we have been able to secure records of them. It will be seen that spotted fever is a disease of much importance to Montana and it should be realized that it is not only a matter of health of our citizens but that its presence in a community has a marked effect upon property value and is, therefore, an economic question of the first importance.

I believe that excellent progress has been made in tick control in the Bitter Root Valley. The number of cases has been greatly reduced. Property values have been very favorably affected and business conditions generally are rapidly losing the unfavorable effect of the presence of this disease. The Board of Entomology is of the opinion, however, that we have reached such a stage in our work that it is now imperative to conduct certain investigations, as we shall be marking time until they have been undertaken.

The investigation necessarily groups around the central question, "What is the origin in nature, or ultimate source, of this disease?" If there were no human beings in the Bitter Root Valley the spotted fever disease would go on just the same, being transmitted by ticks from one animal to another. Just what animal or animals are concerned in the question we cannot say. Under laboratory conditions, besides the guinea pig and the Belgian hare, both of which are domesticated animals, investigators have shown that the following animals can be infected or are susceptible to the disease:

The ground squirrel, **Citellus columbianus.**

The rock squirrel, or side-striped squirrel, **Callospermophilus lateralis cinerascens.**

The chipmunk, **Eutamias luteiventris.**

The mountain rat or wood rat, **Neotoma cinerea.**

The weasel, **Putorius arizonensis.**

Dr. Parker has added to the list the snowshoe rabbit, **Lepus bairdi,** the cottontail rabbit, **Sylvilagus nuttalli,** and the prairie dog of eastern Montana. It is of the greatest importance to know before we proceed further just what the responsibility of each of these and of other native mam-

mals of the Bitter Root Valley is in the spotted fever cycle in nature. We are certain that conditions exist back in the mountains bordering on the Bitter Root Valley which will make it impossible for us to eradicate spotted fever from the valley without further knowledge of just what is taking place in nature. We need to know where the ticks get the infection which is conveyed to man when man accidentally becomes bitten by a tick.

It should be pointed out that the plans which are proposed for inaugurating a line of investigations are not new. We have for years seen the necessity of conducting these investigations but have not been able to do so on account of circumstances. In the year 1910 we had plans for taking up this work in a field station in the Bitter Root Valley when the death of Dr. Ricketts, due to infection from typhus fever which he was studying really as part of his investigation of spotted fever for Montana, prevented. Dr. Ricketts' assistant, Mr. Moore, came to Montana to make preliminary arrangements and open the laboratory. We were to have had a cooperative laboratory near Florence on the old Miles place. The camp was to include a representative of the Biological Survey, an entomologist, and a pathologist. After Mr. Moore's arrival Dr. Ricketts died and Dr. Moore was recalled. Following is an extract from a letter to Dr. T. D. Tuttle, former Secretary of the State Board of Health, which shows the plans we had in mind:

"We also arranged for a representative of the Bureau of Biological Survey to come to the state and study the mammalian fauna of the Bitter Root region and make notes on the local distribution and habits of the various species. We have made preliminary arrangements for the establishment of a camp, or field station, in the Bitter Root Valley and will place Mr. King and the man from the Bureau of Biological Survey in this camp. We very much hope that the Board of Health, through Dr. Ricketts, may be able to continue the work on the disease. I am, of course, working only on the tick side of the problem. In behalf of the Bureau of Entomology and of this institution, I would extend to you an invitation to have a representative in the camp. Dr. Ricketts has indicated to me that he desires to do some other field work."

The plan was carried through excepting that Dr. Ricketts and Dr. Moore were not with us and much important information which we had hoped to obtain was never secured. It is now our intention to undertake to study the disease cycle in nature in the hope that there will be pointed out a way by which we can eliminate or control the disease back in the mountains, as otherwise the Bitter Root Valley will always be menaced by the conditions close upon the valley.

The studies conducted in the Bitter Root Valley will be of value also in solving the problem of eastern Montana. Dr. Parker has secured much valuable information regarding rabbits and has pointed out in a paper read before the health officers of Montana in the summer of 1919 that these animals may possibly be the source of the disease in nature.

Heroic Sacrifice.

Knowingly and without hesitation a considerable number of scientific men have taken up work on spotted fever, and the tick which conveys it, in spite of the danger which attends. Four of these up to the present time have lost their lives in the work. They are Howard Taylor Ricketts* of Chicago University, Thomas B. McClintic of the U. S. Public Health Service, an assistant at the Rockefellow Institute, whose name has been withheld, and, finally, on June 14, 1919, Arthur Howard McCray. Of these, Dr. McCray alone was in the service of the State and was a Montana man. For this reason Montana people take an especial interest in the heroic sacrifice which he made and treasure his memory. The bare facts are impressively eloquent.

Doctor Arthur Howard McCray, State Bacteriologist, Lieutenant M. C., U. S. N. R. F., was born on November 14, 1880, and died June 14, 1919. While engaged in his official duties for the people of the State of Montana in his laboratory at Helena he became infected with Rocky Mountain spotted fever with which he was working in an effort to advance our knowledge of this most baffling disease and save the lives of our citizens. We cannot improve upon the words spoken by the Rev. James F. McNamee of Helena in his funeral discourse:

*Dr. Ricketts died of typhus fever contracted while investigating that disease. This investigation, however, was really a part of his studies on Rocky Mountain Spotted Fever.

"Many a great thought has been uttered without premeditation. Many a splendid life has been lived without planned program toward fame. That which was said of the 'Master of Men' can be said in varying degree of others in every generation. It has been given to some men and some women to redeem our dull and wavering faith in humanity, and to redeem ourselves from our selfish selves. These personalties are like love stars in a murky night, cheering the pilgrim to his shrine. They remind us that there are such things as heroism, chivalry and romance among us; that all the gems of poetry are not contained in books of a past generation; that all heroism is not peculiar to the Argonne Forest, the Somme, or Chauteau Thierry.

"Here, among these towering mountains of Montana these immortal words find new setting. Here Doctor Arthur H. McCray gave his life to save life. Indeed, he saved others, but himself he could not save. It is heroic, sacrifical, unselfish, brave. This business of saving others is dangerous business. It is dangerous in war. It is dangerous in peace. The noble professions of physician and the nurse stand at the very head of the world's benefactions. They meet the serious phases of pain, despair and hope. There are few smiles, little laughter, and less jesting in the sick room. The sick room is everywhere. There are dangers there, too.

"Dr. McCray was in dangerous business, as others have been in the same line of special work in Montana. He gave himself completely to his special work. If he could not save himself, he has left a heritage of example, endeavor and result, that will enable others to save many. This is the glory of life. Life is good. It is not counted by years but by deeds. It is good to live.

"He loved life and its work. He made a brave fight for his own life. He lost, but others shall gain. All through his delirium he was at work in the laboratory. He talked about the formulae for prevention and cure. His own fever was 106. He knew it not. In his dreams he was working out his experiments to the end that others might be saved.

"To his splendid little wife who ministered at his side, to his little mother who arrived here a few moments after the 'Little Doctor of the New School' passed away; to other members of the family who came here for this hour, we pledge our sympathy and our prayer."

ARTHUR HOWARD McCRAY
Born November 14th, 1880
Died June 14th, 1919

"We lay him away among the mountains of Montana. It was his wish. The glorious trinity—grandeur, beauty and reverence—of these mountains will guard his resting place. Here, as nowhere else in this great country, these guardians of his earthly sleep tell the story of their birth, the story of the new birth of this commonwealth, the pioneers who, inured to hardship, compelled the wilderness to blossom as the rose, and compelled the foundations of the everlasting hills to yield their treasure. Aye, he sleeps his last restful sleep among men and women of generous mood: May he rest in peace. This is our prayer for the little—yet big doctor of the new school."

The members of the Board of Entomology, speaking for ourselves personally as his former associates, and officially for the people of Montana for whom he died, desiring to pay to his memory a suitable tribute, feel the impotence of even the most eloquent of utterances.

In order that our people may ever have before them a memorial to his life and to the quality of his sacrifice, and at the same time to place before our youth an incentive to the very highest in human attainment, the Board of Entomology recommends that a tablet be erected by the legislature in the new Board of Health building on the capitol grounds.

The Germ of Spotted Fever.

Previous reports of the Board have mentioned the work of Dr. S. B. Wolbach of Harvard Medical School, Boston, who under the auspices of this Board has conducted extensive studies on the pathology and etiology of spotted fever. Since the appearance of the last Biennial Report, Dr. Wolbach has published his mature results under the title, "Studies on Rocky Mountain Spotted Fever", which appeared in the Journal of Medical Reserch, Vol. XLI, No. 1, pp. 1-197, November, 1919. This extensive paper contributes much to our knowledge of spotted fever and is particularly of interest as it announces the discovery of the germ of this disease to which Dr. Wolbach has given the name of **Dermacentroxenus rickettsi.** The discovery of the organism is a long step in the progress toward a fuller understanding of the disease and its control or eradication.

Appropriation Needed.

Detailed budget estimates for the coming two years have been submitted through the proper channels. The appropriation, per year, for the last two years was $8,500 and the budget requests amount to $22,530.00 per year. The larger sum is made necessary by the requirements of the investigations and control, both of which should be pushed.

REPORT OF TICK CONTROL OPERATIONS IN THE BITTER ROOT VALLEY DURING THE SEASONS OF 1919 AND 1920.

R. R. PARKER, Ph. D., Assistant Entomologist.

Three seasons have now passed since the federal government withdrew its aid from the task of controlling Rocky Mountain spotted fever in the Bitter Root Valley. For lack of funds, during the season of 1918, the State Board of Entomology, upon which the work devolved, could do little besides maintain an interest in the work among the residents of the infected areas and to get together the necessary data for initiating a suitable control program the following year. An increased appropriation and the passage of Chapter XXVII of the Session Laws of 1919, amplifying the duties and authority of the Board of Entomology, permitted the adoption of the prepared program. This has now been in force two seasons and, in spite of limited funds and other unfavorable conditions, material progress in the control of the wood-tick has been made. Certain phases of the work, however, have necessarily been curtailed because of increased cost of labor and of materials. This has been unfortunate but unavoidable. The most serious result of this retrenchment has been the practical suspension of certain lines of investigation which it was hoped would point the way toward a simplified and more rapid program of control.

Since writing the last biennial report, the general plan of control has been improved and amplified. In the present report this plan will be outlined in as much detail as possible and the future possibilities of the work will be discussed.

The writer desires to acknowledge his gratitude and appreciation to the Bureau of Biological Survey and to their recent representative in the state, Mr. George R. Roosevelt, for much needed cooperation and financial assistance for work on federal land; to Mr. W. W. White, District Inspector, United States Forest Service, for continued interest and cooperation in many ways; to the County Commissioners of Missoula and Ravalli Counties for their public spirited support of the work and the appropriation of funds to cover the expense of rodent extermination; to the officers of the

Ravalli County Farm Bureau for their interest and support; and to the many farmers and residents of the areas affected who have loyally supported the work.

General Plan of Control.

The control of the Rocky Mountain spotted fever tick has been a difficult problem to place upon a practical and effective working basis. This has been due to the highly complicated life cycle and host relationship of the tick, as well as to climatic and economic conditions. Not only must the control system be effective, but it must be economically feasible. Therefore, before discussing the control methods now in use, it is necessary to briefly outline the factors which have determined their adoption.

The tick is found in four distinct stages of development —the egg, the larva or seed tick, the nymph, and the adult (male and females). The eggs, 2000 to 7000 in number, are deposited on the ground under rocks and litter during the spring and even into the early summer. These eggs upon hatching produce larval or seed ticks, minute forms smaller than a pin head. They feed only on the blood of rodents and only those fortunate to get upon a rodent host develop any further. The remainder eventually die, very few surviving the winter. Those which secure a host feed from one and one-half to several days, finally dropping. The remainder of that year and the following winter are passed in a quiescent condition, the tick appearing the next spring as the nymph, a form somewhat larger than the seed. The nymph repeats the history of the seed, except that it usually feeds for a day or so longer. The next spring the adult ticks appear, approximately two years after the eggs were deposited. The adult ticks are sexually differentiated and able to reproduce. Unlike the immature forms, they feed on the larger animals, principally on horses, cattle and sheep in the control areas, though sometimes found on certain of the larger rodents. In the mountain areas mountain goats, bears, and coyotes also serve. The male tick must feed on blood before it is able to fertilize the female and similarly the female must feed on blood before its eggs develop. The minimum period of engorgement is usually about 10 days, the actual time depending on a variety of conditions. Engorgement completed, the female drops to

the ground and after a necessary interval deposits its eggs. Adult ticks not securing hosts will live from two to four years. The life cycle, then, may take from two or four or more years for completion.

The salient features of this life history from the standpoint of possible control are these:

(a) The tick feeds only on blood and furthermore only on the blood of mammals;

(b) A different host is required by each of the three stages of the tick and each stage feeds only for a few days in each of three successive seasons and is present only at certain times during the season;

(c) The two immature stages **feed only on rodents**, the adults feed almost entirely on large mammals and principally on horses, cattle, and sheep in the particular area concerned.

Because of the long life cycle and the long periods of dormancy, it is apparent that the only way the tick can be fought is through the medium of the hosts upon which it feeds. That is, it is easier to attack the animal which feeds the tick than it is the tick itself. It is apparent, then, that there are two avenues of attack:

(a) By starvation of ticks, i.e., by killing off or otherwise eliminating the hosts so that the ticks will eventually die of starvation (this method may be termed indirect);

(b) By killing the ticks on the host animals (this method may be termed direct).

Immature ticks can only be attacked by the indirect or starvation method, i.e., through the elimination of their rodent hosts. Adult ticks may be starved (by the control of domestic animals) or they may be killed while on their hosts. In practice both immature and adult ticks are attacked and the control methods may conveniently be discussed under the headings "Immature Tick Control" and "Adult Tick Control".

1 a. **Immature Tick Control.**

As indicated above, immature ticks can only be attacked by the indirect or starvation method. This means the attempted eradication of their rodent hosts. These hosts are ground squirrels, woodchucks, pine squirrels, chipmunks, cottontail rabbits, snowshoe rabbits, and others of less im-

portance. However, on fully 90 percent of the area now being worked, it has been found that ground squirrels are either the only rodent hosts present or are so predominant that other species are unessential factors. In fact, taking the present control areas as a whole, ground squirrels are unquestionably directly responsible for 95 percent of the ticks and indirectly for probably at least 98 percent. By indirectly it is meant that where ground squirrels are abundant and the adult tick infestation is correspondingly heavy, then rodents other than ground squirrels carry many more seeds and nymphs than where ground squirrels are scarce and adult ticks infestation correspondingly low. Thus, when the ground squirrel population has been eliminated and the adult tick infestation has correspondingly decreased, then there is more than a commensurate decrease in immature tick infestation on the remaining rodents. In other words, on most of the area involved, immature ticks can be starved out and thus prevented from becoming adults by simply exterminating the ground squirrel. These are some comparatively small, localized areas, however, where the ground squirrels have less to do with the presence of adult ticks. This is particularly true of certain areas in the canyons and of jackpine areas, the latter, for example, being the headquarters for the snowshoe rabbit.

The starvation of immature ticks by exterminating ground squirrels and other rodents, then is an important means of tick control, and, under the program now in use, it is the major project for the control work. It will be discussed more in detail under the heading, Rodent Control.

1 b. **Adult Tick Control.**

Adult ticks may be controlled by both the direct and indirect methods.

The indirect, or starvation method, has two lines of approach:

(a) The restriction of grazing on infested areas during the season of adult tick activity (March 1 to about June 15) each year for a sufficient period to insure the dying off of the ticks;

(b) The use of repellants on domestic animals to prevent the ticks from attaching;

(c) Quarantine.

The direct method, that is, killing the ticks while fastened to the host, can be utilized by:

(a) Dipping
(b) Handpicking
(c) The application, directly, of toxic substances.

II. Rodent Control.

The subject of rodent control is of great importance because, all exigencies considered, the destruction of rodents offers the surest means of controlling the wood-tick and of eradicating Rocky Mountain spotted fever from the Bitter Root Valley. All other control measures are directed against the adult ticks and are considered as centering about the rodent work, each a necessary feature and important when circumstances indicate its use.

2 a. Ground Squirrel Control.

The reasons why the Columbian ground squirrel, of all rodents, is the most essential to elimin....ate, have been presented under the heading, Immature Tick Control.

The importance of ground squirrel control was recognized by those in charge of the work prior to 1918. At that time, however, it was not considered feasible to use the poisoned grain except in the early spring and just prior to aestivation. At other times trapping, shooting, and carbon bisulphide were employed, all slow and expensive.

As the writter found conditions in 1918 two things were necessary to place the ground squirrel work on a basis which could be made the foundation of the tick and fever eradication work. One was to find a poison formula which could be used at all times during the squirrel season, and the other to secure legislation making it possible to enforce eradication work on each separately owned land area. The great importance of the latter step was pointed out in the Third Biennial Report. A satisfactory formula was evolved and its efficiency proved by comparative experiments, while the lack of authority to make the control work effective was remedied by the passage of Chapter XXVII of the Session Laws of 1919. This law, which appears in this report, empowered the State Board of Entomology to pass regulations requiring the owners of land in the several control areas to

exterminate ground squirrels or other rodents at such times and by such means as prescribed by the Board. When the owner refused or neglected to perform the necessary work, the Board was empowered to do same through its representatives. To cover the cost of this delinquent work the County Commissioners of any county concerned were authorized to appropriate a sufficient amount from the general funds of the county. The cost on each piece of land can be assessed and collected as taxes, so that all the funds expended are returned to the county treasurer. Thanks to the passage of this law, real progress in "gopher" extermination has been made during the seasons of 1919 and 1920. Due to the long cycle of the tick, the effects were only moderately apparent this year, but from now on will become increasingly evident each season.

In 1919 the commissioners of Ravalli County appropriated $3,500.00, and in 1920, $3,000.00 to cover the cost of delinquent work. In 1920 Missoula County appropriated $700.00 for work in the new O'Brien Creek district.

The extent of the ground squirrel work the past two seasons can be appreciated by a study of the following tables:

GROUND SQUIRREL CONTROL IN RAVALLI COUNTY CONTROL AREAS.

	Acres Poisoned		Quarts Poison	Hours Labor	No. Baits Put Out	Average Baits per Acre per Treatment	Average Cost per Acre per Treatment
	once	twice					
1919	44,396½	40,547⅓	2,798	4,283	266,611	3.17	$.0378
1920	48,299	40,983	2,308	4,395	209,521	2.35	$.0329

1919—Additional poison purchased by residents, 1,204⅓ quarts.
1920—Additional poison purchased by residents, 522⅓ quarts.
1920—Poison spread without charge, 151 quarts.

GROUND SQUIRREL CONTROL ON FARMS BETWEEN CONTROL AREAS AND BITTER ROOT RIVER, AVALLI COUNTY.

(In Co-Operation with the Ravalli County Farm Bureau)

	Acres Poisoned	No. Farms Poisoned	No. Qts. Poison	Hours Labor	No. Baits Put Out	Average Baits per Acre per Treatment	Av. Cost per Acre
1920	15,460½	136	819½	828½	75,021	4.85	$.0393

Additional poison purchased by land owners, 152 quarts.

GROUND SQUIRREL CONTROL IN O'BRIEN CREEK DISTRICT, MISSOULA COUNTY.

	Acres Poisoned		Number Farms, etc. Poisoned		Quarts Poison	Hours Labor	No. Baits Put Out	Av. Baits per Acre per Treatment	Av. Cost pe Acre per Treatment
	once	twice	once	twice					
1920	9670½	8930½	41	36	581	901	40,905	2.19	$.0308

Additional poison purchased by land owners, 82 quarts.

Besides the work indicated by the above tables, 25,000 acres of Natural Forest was poisoned in 1919 and about the same acreage again in 1920. This work was performed in cooperation with the Federal Bureau of the Biological Survey and its significance and importance are discussed elsewhere in this report.

Counting land which was poisoned twice, approximately 109,943 acres were treated in 1919 and 148,434 in 1920. The average cost per acre has not exceeded $.04, though of course varying above and below that figure for individual areas.

In the O'Brien Creek area which was systematically poisoned this year for the first time it will be noted that the cost was about 3 cents per acre, the lowest average indicated. The infested gopher areas in this district are more restricted than in the Ravalli County areas and hence are more satisfactorily poisoned. Where infestation occurs, on the other hand, it is much heavier than in the older districts and the tick infestation correspondingly bad.

The land between the districts and the Bitter Root, now in Ravalli County shows the heaviest infestation, 4.85 baits per acre having been used. This land has been neglected so far as systematic work is concerned for several years, as is witnessed by the figures given.

The following is a general outline of the manner in which the ground squirrel control is conducted. The deputies in charge of each district are intrusted with the supervision of the "gopher" work in the territory under their charge. They hire and discharge their men. The deputies, furthermore, plan the work for their men and check up on the results secured. Each deputy is furnished with a special set

of instructions for his territory. Each poisoner is provided with outlined exhaustive written instructions and with a photographic map of the district in which he is employed, showing the boundaries and acreage of each separately owned piece of land. He is also provided with a notebook in which a record is kept of the number of hours of labor, number of quarts of poison, and the number of baits used on each place. Notes are also kept of the degree of infestation, the number of ticks "picked up", etc. These cards are eventually filed as a part of a permanent record concerning each farm or other land area. At the end of each month each poisoner prepared duplicate sworn lists designating the areas worked upon and the amount of poison and labor expended upon each. One list is retained by the Board and one placed on file with the County Treasurer. From these lists permanent records are prepared which show a comparatively yearly record. This list is valuable in many ways. During July a statement of expense against each parcel of land treated is prepared for the use of the County Treasurer. This is accompanied by a bill to be mailed to the owner of land area concerned.

During the seasons of 1919 and 1920 two poisonings have been required, the first during the first 20 days of April, the second during the first ten days of June. In 1921 it is hoped that one poisoning will be sufficient.

The poison used is prepared at the field station at Victor and is sold at cost. The high price of strychnine since the war and the increased price of oats and saccharine have served to make the price much higher than it would have been had normal conditions prevailed. The price thus far has been 30 cents per quart.

Owners desiring to poison their own land are permitted to do so, but if efficient work is not done, our policy has been to repeat the work. It is very seldom that a farmer will use sufficient poison.

The law provides a limit of 5 cents per acre for any one treatment. The limit allowed by law for similar work in other localities in the state is 7½ cents. Usually it has been possible to keep within the 5 cent limit. Reference to the table given above will show the comparatively low cost of the work. Many owners have preferred turning it

over to our men rather than to attempt to do it themselves. On the few acres on which it has been impossible to keep within the limit the extra expense has been supplied from state funds.

It has been the writer's practice to encourage complaints of inefficient work. In such cases men under state pay have been utilized to repeat the work. Poor results are not always the fault of the poisoner, but may be due to climatic factors or to idiocyncrasies of the squirrels.

It has been difficult to obtain as good men as needed to spread the poison. Trustyworthy men are much to be desired in work of this kind. Carelessness may lead to serious results. Fully half the men hired have been discharged for inefficiency.

Too much emphasis cannot be placed upon the value of the cooperative spirit shown by the Federal Bureau of Biological Survey and their local representative, Mr. George A. Roosevelt. The fact that the west boundary of our control erea is a national forest boundary has led to much justified criticism because the squirrels keep migrating down into the valley from the federal land. Besides this federal forest land there are also about 7,500 acres of federal land within the control areas. In 1919 the Biological Survey furnished $579.00 to cover the cost of two poisonings on the 7,500 acres within the districts and also paid for the labor and materials necessary to poison a strip of forest a mile wide bordering the districts on the west—approximately 25,000 acres. About $1,500.00 was thus expended by the federal service in 1919. In 1920, due to a reduction in funds, the amount contributed by them was only about $800.00. While it was not as much as had been hoped for, it was nevertheless a very material aid.

The squirrel infested areas in the forest that are most troublesome lie along the edge of the control districts and in most places are included within the mile wide strip noted above. Beyond this strip the squirrels are scattered and for the most part only occur in occasional towns of greater or less size where they find conditions favorable. It is highly desirable that these towns be cleaned up west to the divide along the Montana Idaho line. In 1921 it is hoped that

it will be possible to extend the control area south to Chaffin Creek. If this proves feasible it will increase by one half the extent of federal land bordering the districts.

During the season of 1920 men in our employ poisoned 15,460.5 acres of land that lies between the east boundary of districts and the Bitter Root River. Land owners along the east boundary have very naturally complained because they were doing their best to exterminate the squirrels while their neighbors across the boundary were often negligent. Thanks to the cooperation of the Ravalli County Farm Bureau, it was possible to poison this land in the same manner as that within the district limits.

Mention has already been made of the fact that land where efficient work has not been done has been treated again free of expense to the owner. Each district man also carries a 22-caliber rifle and is supplied with ammunition and instructed to shoot every gopher seen. Thousands are killed each year in this manner. Unfortunately it has been impossible to spare money for as much ammunition as could be used. Occasionally shooting is necessary on sheep pastures when poison might not be safe.

There has been no little agitation concerning the possible poisoning of birds by means of the "gopher" poison. The forty or more men employed during the past two seasons have been instructed to turn in written reports of all birds poisoned by eating the grain. Three such reports have been received, two bluejays and one magpie, each verified by an examination of the stomach contents. Suffice it to say that all our experience points to the utter absurdity of the claims made.

2 b. Control of Other Rodents.

Except that gopher poisoners are instructed to put out poison for rabbits and woodchucks wherever seen, the control of rodents other than ground squirrels falls on the district deputies. The latter, as previously noted, carry 22-caliber rifles and have instructions to shoot every rodent seen, particular stress again being placed on the two first mentioned. The ground squirrel poison is not very attractive to these rodents, though they occasionally take it. Especially prepared poisons are necessary for them. Rabbits are most successfully combatted during the winter. In the absence

of ground squirrels, these animals are frequently responsible for the occurrence of ticks on certain localized areas of certain types, and their control or extermination is essential. Side-striped squirrels take the poisoned grain quite readily. They are not a serious tick factor, however, except in certain portions of the O'Brien Creek district. Pine squirrels and chipmunks are among the rodents which are killed wherever possible.

Residents are also requested to destroy these animals.

III. Grazing Control.

Next to rodent extermination the control of grazing on infested areas is the most efficient method of tick control, but it is only possible of limited application. The basic principle of control is to prevent the engorgement of the adult tick on domestic animals, whether it be accomplished by exterminating rodents and thus preventing the tick from ever becoming adult, by prohibiting grazing, by dipping to kill infesting ticks, or by some other means. If it were possible to keep all domestic animals from the infested areas until after July 1st of each year for a series of years, practically one hundred percent efficient work could be accomplished. This, however, is economically impossible. The only course open is to use this control measure where circumstances permit. Section 9 of Chapter 27 of the Session Laws of 1919 empowers the State Board of Entomology to make regulations to prohibit or control grazing on unfenced land within the limits of any control area. In accordance with this authority, the Board passed Section 3 of the Regulations which prohibits grazing on unfenced land without a permit. This regulation was intended to keep stock off the waste land and foothill areas west of the farm land, this territory being the most heavily infested with ticks and the most dangerous from the standpoint of possible infection.

During the season of 1919 this regulation was enforced quite religiously, permits being issued for milk cows only in a few instances where the owners were without pasture. It became apparent, however, that in some instances an undue hardship was being placed upon some owners having range cattle. Therefore, during the season of 1920 certain grazing areas along the foothills were selected which were fenced on the east, and on the south and north either fenced

or bounded by natural barriers. Steep mountain slopes prevented travel toward the west. Permits for the use of these areas were issued to persons needing them under certain stipulations which varied with the conditions. In the case of horses and cattle, dipping or the use of repellants was required, while in the case of sheep the pastures were to be kept gopher free.

In 1921 it is expected to remove all restrictions on milk cows, conditional upon the use of repellants. This becomes possible because the writer has found that the use of certain oils will practically keep stock tick free. As soon as means can be developed to use these oils satisfactorily on range animals all restrictions can be removed.

There have been a number of violations of the grazing regulations during the past two seasons, some deliberate, many unintentional. Complaints have been filed against three stock owners, all of whom have pleaded guilty and paid fines without the cases going to trial.

In the O'Brien Creek area there were practically no stock this season. In previous years cattle or sheep have been numerous. Since it was impossible to place a deputy in that area, this absence of range stock was exceedingly fortunate.

The O'Brien Creek area contains few resident owners and is, for the most part, made up of mountainous country. The worst tick infested areas are range country and non-agricultural. Once the owners of this land are deprived of the use of this range, their holdings become worse than valueless. Hence no grazing control is, or is likely to be, feasible in this district.

Any further extension of the work south along the Bitter Root Valley will involve grazing conditions similar to those in the O'Brien Creek country.

IV. Use of Tick Repellants.

During the spring of 1919 the writer started a series of experiments with the hope of finding some substance with tick repelling properties which could feasibly be used on horses and cattle. Various oils were tried and some have given every promise of satisfactory results. The use of oils was suggested because many observations by the writer had

indicated that the natural oils of animals and other oils are repellant to ticks. To illustrate briefly, it may be pointed out that animals in good condition, with an abundant of oil in their skin and hair, are seldom severely infested. For example, cattle are much more severely infested in the early spring before they have shed and their coats have become oily, than later in the season. Many instances have also been noticed in which kerosene and lard, turpentine and lard, (applied for lice) have served to keep animals tick free for long periods.

The experiments of 1919 were of limited extent but indicated that good results might be expected from the use of raw cottonseed and raw linseed oil, the best results coming from the former.

It was intended to make quite extensive studies in 1920 but the writer's absence made it impossible to secure the accurate data desired. Some observations, however, were made by assistants and farmers to whom the oils were given to try out. All data secured from the use of raw cottonseed and raw linseed oil indicated complete to almost complete protection, especially with the former. One farmer with 20 cows reported no ticks after starting the use of oil; another with 13 cows reported 4 ticks, but all crawling and none attached; and so on. One herd of 102 head was treated with gratifying results. Crude petroleum has not yet been tried.

On cattle the oil is applied from the base of the horns back to a point about half between the hips and thighs. Between four and five fluid ounces were used per animal.

Further work with these oils is highly essential since they offer a means of making the control work more effective with the probability that the work can be carried on with less demand upon the time of the farmers concerned.

V. Dipping.

Dipping is a direct method of attack, the ticks themselves being killed by poison instead of being starved, as happens in the indirect methods previously mentioned.

In the last biennial report it was pointed out that the greatest benefit which could be realized from compulsory dipping had already been achieved. For this and other

reasons, also indicated, it was desired that more intensive rodent and grazing control be substituted for dipping. As previously noted, the fundamental obstacles to this change, namely, the lack of a suitable "gopher" poison and of authority to compel rodent destruction and to control grazing, were remedied prior to opening of the season of 1919.

The disadvantages of dipping were recognized by the federal representatives formerly in charge, Dr. W. V. King of the Bureau of Entomology, and Dr. L. D. Fricks of the Public Health Service. So far as circumstances permitted, they resorted to other methods. The former with comparatively little range country and fewer range animals in his territory was able to secure sufficient cooperation among the farmers to keep stock from the greater part of the open land until after the tick season. Some stock was even taken to national forest ranges on the east side of the valley. Dr. Fricks, on the other hand, with more land and more stock, was less fortunately situated. The stock owners were much opposed to moving their animals and have consistently maintained this attitude. An unsuccessful attempt to secure authority to control grazing was made by Dr. Fricks in 1917. The control now exercised is not as rigid as would be most beneficial but is all that seems justified in the opinion of the writer.

The past two seasons the six vats now in use have been filled and persons permitted to dip as desired. This dipping has been in addition to control measures required. Compulsory dipping has been enforced when permits have been issued to owners to range stock on the foothill areas designated for grazing and in connection with quarantine measures.

It is not desired to minimize the importance and effectiveness of dipping. As an accessory control measure it is very helpful. Almost 12,000 head of stock have been dipped the past two years (inclusive of sheep), more, it is believed, than was the case when there were more horses and cattle in the country and dipping was a compulsory feature of the work. In no case has a single animal been injured.

The vats and vat corrals are in sad need of repair. Our limited funds have not permitted that they be kept in good condition, Some of them have reached a point where repairs are an absolute necessity before further use is possible.

VI. Handpicking.

Section 6 of the regulations of the Board requires that dairy cows and work horses shall be freed of ticks at least once each week between March 1st and July 1st by handpicking, Ticks removed must be destroyed. The removal of ticks from such animals is a very material aid in reducing the infestation in the farming portions of the control areas. The rigid inforcement of this regulation is an utter impossibility but most residents are sufficiently interested to keep close watch of their animals. Many owners are careful to remove the ticks each day, which is much the better plan but scarcely feasible to incorporate in a regulation. There are some who pay no attention to ticks on their stock and do great harm to the work by their neglect.

VII. Application of Directly Toxic Substances.

The expression "directly toxic" is used to designate substances which kill the tick by coming in contact with it, in contradistinction to arsenic in dipping solutions which presumably first enters the blood of the host animals and then is taken in by the ticks. This is a direct control method and has little value, except under local conditions. No substance for this is recommended. Various substances are occasionally used in this way by the farmers, however. For instance, I have seen equal parts of turpentine and lard used, with deadly effect upon the ticks, on calves "down with ticks".

VIII. Quarantine.

Section 8 of Chapter 27 of the Session Laws of 1919 make each control desrrict a quarantine area between March 1 and July 15 of each season, the movement of domestic animals into or out of districts being prohibited unless accompanied by a permit. However, "animals ridden under the saddle or driven in harness or under yoke" are not subject to this quarantine. This provision merely made a law of what was previously a regulation of the Board of Entomology. The idea of this law is not to interfere in any way with the business affairs of stock owners, but simply to make sure that animals entering or leaving the control areas are tick free.

IX. Follow-Up Work.

One of the most essential features of the control program, and because of the financial stringency one which receives little attention, is termed "follow-up" work. Its purpose is to determine the progress which is being made in tick control, and to furnish a comparatively yearly record of tick infestation on each land area. There are two avenues through which this information can be secured, namely, immature and adult tick surveys.

Data for the adult tick surveys are obtained from the following sources:

(1) Examination of stock.
(2) "Dragging".
(3) Poisoners' reports.
(4) Reports from other sources.

Examination of Stock. When laying out the control program it was the intention that work horses, dairy cattle, and sheep (whenever feasible) should be regularly and systematically examined for ticks. This has proved to be an impossibility because of insufficient assistance. The result has been that records of this nature have been more the outcome of chance observation than of systematic effort. Occasional animals are encountered that can be examined in the field and information is sometimes picked up from owners and renters.

"Dragging". When conditions permit, "dragging" is the most reliable means of estimating tick abundance and the extent of infestation. Unfortunately, this procedure is not feasible on rainy or windy days or when the weather is otherwise seriously inclement. Neither are records reliable for long after the middle of May for the ticks begin to enter aestivation about that time. Hence, there are available for this work a comparatively few days during the early spring. These days it is exceedingly difficult to take advantage of. The only men available for this work are the district deputies and they have a multiplicity of other and pressing duties. Furthermore, each deputy has from 15,000 to 30,000 acres in his charge, and even under the best of conditions could not complete a survey of this character in the time available.

Poisoners' Reports. Although very unsatisfactory, most of our reports of adult tick infestation come from records kept by the "gopher" poisoners. The latter are supposed to make a record of the number of ticks they "pick up" on each land area or farm, and such record, if religiously kept each season, would be of considerable value. There are many factors which detract from their usefulness, however. For example, difference in clothing worn by different men, varying weather conditions, and the same areas are not consistently covered each year or necessarily at the same time each year. However, these reports are helpful and constitute the bulk of our adult tick infestation records.

Reports From Other Sources. Deputies, owners and other persons frequently turn in records of infestation. These, other than the records of men employed, are not reliable, but have some indicative value.

Information for the immature tick survey is gained entirely from the examination of rodents which have been shot. Usually only nymphs are found prior to about the middle of June. After this time both seeds and nymphs occur. Besides being indicative of the rate of progress being made, these surveys serve as a check both on our own work and on that of the land owner, as the case may be. The deputies are able to devote more time to this survey, but the increasing scarcity of ground squirrels is making it difficult to secure records.

If these two surveys could be conducted in the manner desired they would result in records of inestimable value for use in future operations. Lack of funds and assistance render this impossible. If it were feasible to employ two men specifically for this work for two or three months each spring, this condition could be remedied to a large extent.

X. Progress of Work.

To present actual figures illustrating the progress in tick reduction is impossible. This is largely because it has not been possible to make systematic adult and immature tick surveys as just discussed. That substantial progress

is being made, and that the progress during the past two seasons has exceeded that which was possible in previous years, is perfectly apparent.

In 1917, the year during which the two federal agencies withdrew, about 20,000 acres were released from the districts as tick free. At the present time some thousands of additional acres are either tick free or essentially so. Pertinent reasons, however, make it impossible to release these areas or to predict when this can be done. It will depend largely upon the result of legislative action on certain matters. While definite figures denoting progress cannot be given, it is, however, possible to give certain indicative data. During the season that adult ticks are active one of the most enlightening experiences would be to traverse some of the land in Ravalli County where the work has been going on for some years and then to take a similar trip through the O'Brien Creek area near Missoula, where intensive work was just started this year (1920). In many parts of the former territory ticks are a rarity and infested "gophers" quite scarce. In the latter area ticks are extremely abundant and an uninfested "gopher" is a rarity. In 1920 "dragging" on 13 land areas in the Stevensville district, totalling about 2,500 acres, yielded 8 ticks in 25 hours; twenty-five cows and horses examined gave 10 ticks. One hundred and forty-one ground squirrels examined by the deputy in the Gold Creek district showed 9 infested, with a total of 18 ticks. These figures are from the old districts in Ravalli County. During the first poisoning in O'Brien Creek this spring Frank Cowan, in charge, found 150 ticks on his person during 12 days' work, while of 81 gophers shot by him 44 were infested with 424 ticks. Of thirty gophers shot in the same area by the writer and his chief deputy, G. H. Cowan, on June 26, 28 were infested. Of these, two of which accurate records were kept, carried 75 nymphs each.

To show what can be accomplished by conscientious effort, the results secured by C. E. Davenport, a renter in one of the bad tick areas, can be given. Prior to his occupancy the farm concerned had been deserted because of repeated cases of fever. On April 24, 1918, the writer and G. H. Cowan secured 175 ticks in one hour's "dragging" on this land, finding ticks almost in the dooryard. The poisoning and trapping of ground squirrels, handpicking of horses

and cows, the use of repellants and dipping consistently followed have so reduced the ticks that the occupants of the place "picked up" but three ticks the entire season of 1920.

As far as the attitude of persons living in the infested regions is concerned, there is manifest an increasing confidence. There are still people in the valley, particularly on the east side, who are unreasonably afraid—even to the point of absurdity, and there are still many who refuse to accept the fact that the tick is the transmitting agent. The great majority of the last mentioned group, whatever their verbal opinion, are noticeably careful to guard against tick bites.

The increased sales of land on the west side of the Bitter Root attest more plainly than words the improvement in conditions.

Outside the state exaggerated ideas of the extent and character of the infection are still rampant and frequently come to notice. Unfortunately, unjust though many of these fantastic ideas are to the Bitter Root Valley, yet they are found reflected in the ideas of people about other parts of the state. The increasing prevalence of the disease in eastern Montana lends color to these notions.

The ground squirrel campaign deserves particular mention. During the season of 1918 and 1919 squirrels migrated down from the mountains in considerable numbers, due to the prevailing dry conditions. Since these migrations occurred largely after the poisoning was over, they made the results of the work appear to less advantage than deserved in many instances. At the same time these migrations were a distinct advantage in that squirrels which we would have otherwise had to poison in rough mountainous country were brought down where they were easier to combat. At the present time the reduction on the whole area may be estimated to be at least 80 to 90 per cent, while individual cases show more or less. Five hundred thousand "gophers" is a modest estimate of the number destroyed.

It was estimated by Dr. W. V. King, formerly in charge in the north end of the valley, that each gopher was engorging approximately 75 nymphs per season. Probably 0 to 10 per squirrel is an estimate more applicable to present conditions in Ravalli County, depending on location. This means

that millions of nymphs have been prevented from becoming adult and that potential females have been prevented from depositing billions of eggs.

XI. Investigation.

As the person bearing the immediate responsibility for the control operations, the writer has come to feel more and more the need for certain investigations. The greater the advance made in tick control the more this need becomes apparent. The past three seasons scant time and equally limited funds have been available for work of the character needed, and it has accordingly been neglected. It is necessary that this need for investigation be explained.

The present program for the reduction of Rocky Mountain spotted fever aims at the elimination or control of the transmitting agent, **Dermacentor venustus** Banks. Until very recently not only was no other avenue of control apparent but there seemed no immediate likelihood of such. So far as our knowledge goes, then, tick control has been and still is the only feasible means of keeping down the number of cases. But let us suppose that the time comes, and it is not far distant for the five original control areas, when ticks will have either been eliminated or so far reduced that human infection becomes an improbability. We shall then have accomplished what it was originally hoped to do. What is the next move? Shall the various areas be released as fast as cleaned up? And if they are released, what will be the result? Will it not mean that whatever is thereafter done to keep the ticks down **will be the result of just so much effort as the resident farmers see fit to expend?** What the results will be can safely be forecasted to some extent.

First, the farmers will do little of real value. This will be due to the natural difficulties which always intrude when leadership is removed, and above all to the fact that certain physiographical and economic factors, which need not be specified here, make it an essential impossibility for effective work to be done without organization, especially when our knowledge of the real source of the disease is not more definite than it is at the present time.

Second, ground squirrels will migrate in from the surrounding country, especially from the national forest to the west, and other rodents, in particular, will multiply undis-

turbed. Ticks will gradually be brought in and will slowly increase.

Third, while it is impossible to predict with certainty just what the result will be regarding the recurrence of the fever, there is every reason to expect that it will reappear with the return of the ticks and their rodent hosts to the same local areas now concerned. That anything else would happen would not only be unexpected but very surprising and contrary to experience regarding the disease **in the locality concerned.** That it would perhaps not become as bad as in times past might also be expected for a number of reasons.

Without going into the various ramifications of the subject suggested by these probable facts the writer will point out that the one big question which arises and which has absorbed more of his time and thought than any other is, "Can the results of the work in any way be made more permanent?" Mature consideration has led the writer to believe that they can, and therein lies the need for one of the most interesting pieces of investigation of its kind yet undertaken. Furthermore, the writer believes that he has an investigation outlined which cannot fail to yield the needed information, namely, "What is the source from which the ticks get the infection?"

I regret that lack of space forbids a detailed discussion of this proposed piece of work and the various factors concerned, but it is possible to set forth a few of the fundamental features which indicate that the solution may perhaps be simpler than one might suppose. In such an investigation the knowledge of the causative agent, **Dermacentroxenus rickettsi** Wolbach, will be of great value. Our certain knowledge of this causative agent is entirely due to the etiological studies of Dr. S. B. Wolbach of Harvard Medical School, who took up this work at the behest of the Board and as a matter of personal interest.

The fundamental fact that underlies the proposed investigation is this, **that given equivalent adult host conditions, the abundance of ticks in any locality is dependent upon the character of the vegetation or of the soil covering** (that is, whether timber, open timber, jack pine, cut over stump land, cultivated land, rocky land, etc., etc.). It is this character

of the soil covering which **not only determines the species of rodents but also their relative abundance.** Under Bitter Root Valley conditions very few species of rodents are what can be termed generally distributed. Mice are most widely spread and ground squirrels next. Other rodents are more or less restricted to certain types of country, that is, **to conditions most favorable to them.** For example, snowshoe rabbits are practically restricted to jack pine thicket areas, woodchucks to rough talus slopes, etc. Thus it is evident that given any particular type of country the ticks present may be presumed to have developed on the inhabiting species of rodents. For example, on waste open slopes ground squirrels predominate and most ticks present will have fed as larvae and nymphs on ground squirrels. Similarly in jack pine thicket areas most ticks will doubtless have fed on snowshoe rabbits, while in woodchuck areas woodchucks will have been largely responsible. Now, since there is every reason to believe that the source of Rocky Mountain spotted fever is to be found in some one or more species of rodents and since the distribution of the fever is restricted to certain types of country, is it not reasonable to assume that the rodents inhabiting areas of that particular type in which the fever occurs are much more likely to be related to the occurrence of the disease than are those in types of country in which the fever is not present? This brings out a point much misunderstood—that the fever has not been generally distributed on the west side of the Bitter Root Valley, but seems to have been restricted to certain quite well defined areas. These are the basic facts which form the foundation of the proposed investigations. It may be added that evidence accumulated by the writer points toward snowshoe rabbits as the real culprits. This evidence is entirely circumstantial, however, and the investigation has been planned in a sufficiently broad manner to neglect no possibility.

Imagine that such an investigation has been completed. Will the knowledge gained help to make fever control work more permanent? There is every reason to believe that it will. Let us suppose that the present area in which the work is being conducted has been cleaned up, that ticks are scarce or eliminated and the guilty rodent exterminated. Then to keep the fever down the essential point will be to

prevent the return of the guilty rodent. What matter if ticks do come in if the actual source of the disease has gone and can be kept out? Personally I do not think it will be feasible for some years to withdraw all supervision, especially so long as tick control is the basis of the work, but, if it should be necessary, the farmers could do much better toward keeping infection out if they knew that some definite animal or animals had to be guarded against, and not a long list of rodents, some of which they could scarcely ever see even if they were present. Again, let us suppose the snowshoe rabbit were found guilty. Because of its restricted distribution and its habits it would be the easiest rodent of all to exterminate and the easiest to keep out. It can be easily and inexpensively poisoned and the gradual cleaning of all jack pine country would be a practical insurance against its return.

The greatest value to be derived from such an investigation, however, is that it might show, and indeed probably would, that it is feasible **to control the source of the disease and to do away with the** prolonged program of tick control. Once the necessary knowledge has been gained it is usually much easier to control the source of an infection rather than the disseminating agent. And now that we are in a position, for the first time, to conduct the necessary investigation to determine the source of Rocky Mountain fever with reasonable hope of success, there should be no delay in initiating the work. There is every prospect that the results would mean a considerable saving both to the state and to the land owners of the Bitter Root Valley. Once the source of the disease has been found, much of the air of mystery that has surrounded the infection will have been dispelled. It will no longer be a fight in the dark.

The rapid spread of Rocky Mountain spotted fever into most of the counties of eastern Montana since 1914 has directed considerable attention to that portion of the state. In 1918, as the result of two seasons' investigation in that part of the state, the writer published evidence pointing toward the jack rabbit (possibly implicating the cottontail) as the rodent responsible for the occurrence of the disease in that section. While it is possible, as the result of our work in eastern Montana, to advise individual owners how

to rid their holdings of ticks, any extensive tick control program. such as is being carried out in the Bitter Root Valley, is not only impossible but unwarranted.

The disease in that section can be controlled only through the control of the rodent which is the source of tick infection. Here, then, is additional reason for conducting the proposed investigation. With only a nominal increase in available funds the studies for both sections of the state can be conducted simultaneously.

During the season of 1919 more than 60 inoculation experiments with rodents were carried out. These were in line with the investigations planned and were primarily induced by the evidence that snowshoe rabbits may be the real source of tick infection. It was found very difficult to handle these animals; they are very delicate and often die in a few days when closely confined. However, it was amply demonstrated that these rabbits are susceptible to infection and the possibility of chronic infection was strongly indicated. This occurred in a rabbit which survived both the close confinement and the clinical course of the disease. Pronounced scrotal lesions were still persistent five months after inoculation. At this time the rabbit unfortunately died so that further observations were prevented.

Cottontail rabbits were also shown to be subject to infection but the disease in them was very difficult to diagnose except by blood transfers into guinea pigs. The normal temperature was found to vary between 101 degrees and 104 degrees. The only external manifestations were a slight reddening of the skin and dropping out of the hair, both conditions being most marked in the scrotal region.

Thus far it has been impossible to work with jack rabbits. A number of these animals were captured in November, 1919, and kept till early September of 1920, when it was first possible to start a strain of the fever this season. All these rabbits died, apparently from pneumonia, the night before it was expected to inoculate them. There is every reason to believe these animals susceptible, however, and continued observations in eastern Montana have only served to strengthen the writer's belief that rabbits are responsible for the fever under eastern Montana conditions.

In the past the "gopher" has been strongly suspected of being the rodent responsible for the occurrence of human cases in the Bitter Root. While undoubtedly susceptible to infection the writer believes they have little to do with the incidence of human cases. They certainly are responsible for the feeding of 95 per cent or even more of the immature ticks and it is possible that they indirectly share in the responsibility, but that they are more than a secondary factor seems extremely unlikely. The reasons for this need not be entered into at this time.

Investigations concerning the habits of ticks have demonstrated a tendency of adults to migrate down hill. Under such conditions they are frequently found collected in large numbers on the up-slope side of trails, which they seem indisposed to cross. It has further been found that the factor determining the dropping of engorged seeds is the degree of light intensity. The more intense the light the more rapidly do they drop. These facts have a bearing on the distribution of infected ticks, particularly the reaction of the engorged seeds to light. Nymphs doubtless have the same habit. To illustrate, a non-burrowing animal of nocturnal feeding habits will drop its ticks where it stays during the day. If such an animal should prove to be the real source of the disease, it may help to explain the apparent localization of infection. The snowshoe rabbits would fall in this category. During the day they are found in jack pine thicket country which the writer suspects to be the most likely type of country to harbor infected ticks. Certainly, then, any ticks dropping from them, whether infected or not, will be kept localized in areas of the jack pine thicket type.

Another important line of investigation that has been pursued is the use of repellants to prevent ticks from feeding and engorging upon domestic animals. Mention of the success attending the use of certain raw oils on dairy stock has been made in a previous part of this report. Experiments to determine the possibility of using these oils for range animals are very important. With the possible extension of the work into new areas, the further construction of dipping vats is extremely unlikely for several reasons. If oils can be satisfactorily used under the new conditions to be encountered, it will materially aid, hasten, and simplify the control work in these areas.

XII. Publications and Papers.

A circular entitled "Control Program for 1919" appeared in March of 1919 as Circular 1 of the State Board of Entomology. This circular was designed for distribution among residents of the infested area and contained a brief outline of the control program and the reasons for the control measures now in use. Copies of laws and regulations were also included. One thousand copies were secured. This number was wholly inadequate and all copies were exhausted during the first year of the biennium. This circular needs revision and a much larger number of copies must be secured.

Other papers have been published and read as noted below:

"Present Status of the Control of **Dermacentor venustus** Banks in the Bitter Root Valley, Montana, and New Data Concerning the Habits of the Tick." Read, American Association Economic Entomologists, St. Louis, Mo., January, 1920; published, Journal of Economic Entomology, February, 1920.

"A Possible Source of Rocky Mountain Spotted Fever in Nature." Read, State Health Officers' Association, Missoula, Mont., July, 1919.

"Observations on and Experiments with **Cuterebra tenebrosa** Coquillet." Published in conjunction with R. W. Wells, Journal of Parasitology, 1919.

XIII. Assistance.

The problem of assistance has been a hard one with which to deal due to the nature of work, the short period of employment and recent economic conditions. Two types of men are needed, one for use as district deputies, the other for poisoners. For the former, active, aggressive men are needed, who are thoroughly reliable and willing to work at any time, day or night. They must be able to handle men, to get along with the people with whom their work brings them into contact, to handle cattle and horses, and to absorb and make use of a varied assortment of information. Furthermore, they have to become individually acquainted with each piece of land in their territory (15,000 to 30,000 acres) and its particular problems relating to the control work. To secure men really qualified for this work is very difficult.

Technically trained men are prohibitive. Local men must be engaged and trained. Unfortunately, it has only been possible to give these men employment for about four months each year. This necessarily means that it is a very difficult matter to hold them and, whereas the same man should be in charge each year over the territory with which he has become acquainted, a large share of new men have to be employed each year. This naturally detracts from the efficiency of the work.

Because of increasing cost it was necessary in 1919 to reduce the force of district men from five to three, two of the men being assigned double territory. In 1920 it was necessary to still further detract from the efficiency of these men by requiring them to put in part of their time poisoning gophers so that they could be paid in part from county funds. Their appointment in the spring has been delayed till April 1 whereas the work demands their presence March 1st. This condition cannot persist.

Reliable men for the "gopher" work have also been hard to obtain. The employment is temporary and the wages set by law, $3.50 per eight hour day, not attractive at the present time.

The clerical work has increased by leaps and bounds till the services of a full time clerk are needed. Thus far assistance has been engaged as needed to tide over the busy periods of the work. The assistant entomologist has been obliged to devote so much of his time to the office work that his efficiency has been materially decreased.

XIV. Expansion.

In the spring of 1920 a new district was established including the bad O'Brien Creek area near Missoula. While regular district work was impossible, yet a very thorough program of gopher control was initiated. Better cooperation has been given and more satisfaction over the result of the work has been manifested by the residents of this area than by those of any of the older districts.

If the tick control program is to be carried to its logical end, it is necessary that more of the tick infested areas where infection is present should be gradually included in the control areas. To this end, it is recommended that the area between Lost Horse Creek (our present south boundary in the Bitter Root) and Chaffin Creek be organized into a district in 19p1.